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AUTHORITY

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# MECHANICAL-PROPERTY DATA
# BERYLLIUM

Cross-Rolled Sheet

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This data sheet was prepared by Battelle Memorial Institute under Contract AF 33(615)-2494. The contract was initiated under Project No. 7381, "Materials Application", Task No. 738106, "Design Information Development". The major objectives of this program are to evaluate newly developed structural materials of potential Air Force weapons-system interest and then to provide data-sheet-type presentations of mechanical data. The program was assigned to the Structural Materials Engineering Division at Battelle under the supervision of Mr. Walter S. Hyler. Project engineer was Mr. Omar Deel. The program was administered under the direction of the Air Force Materials Laboratory, Air Force Systems Command, Wright-Patterson Air Force Base, Ohio, by Mr. Marvin Knight, project engineer.

## Notices

## BERYLLIUM SHEET (CROSS-ROLLED)

Beryllium is a light-weight, high-modulus metal that is advantageous for specific aerospace applications. Beryllium does not have the ductility of the more common light metals; however, current production of this material by powder metallurgical techniques results in a metal that can be used.

This material has limited formability at room temperature; however, formability is considerably increased at elevated temperature.

Brazing, mechanical joining, and welding techniques have been used to a limited extent in fabricating beryllium. For each method of joining, specific, detailed procedures must be followed.

Beryllium is available in vacuum-hot-pressed blocks, cross-rolled sheet, strip, plate, wire, and as extrusions and forgings.

Particles of beryllium and its compounds are toxic. Special precautions must be taken in that no inhalation occurs.

### BERYLLIUM SHEET DATA[a]

Condition: Cross-Rolled[b]
Thickness: 0.020-0.063 inch

| Properties | Temperature, F | | | |
|---|---|---|---|---|
| | RT | 400 | 600 | 800 |
| **Tension** | | | | |
| $F_{tu}$ (longitudinal), ksi | 75.0 | 57.9 | 46.0 | 37.3 |
| $F_{tu}$ (transverse), ksi | 76.3 | 56.0 | 45.9 | 37.3 |
| $F_{ty}$ (longitudinal), ksi | 55.4 | 48.9 | 41.2 | 36.6 |
| $F_{ty}$ (transverse), ksi | 54.0 | 47.8 | 41.4 | 36.6 |
| $e_t$ (longitudinal), percent in 1 in. | 8 | 41 | 43 | 23 |
| $e_t$ (transverse), percent in 1 in. | 14 | 35 | 40 | 22 |
| RA (longitudinal), percent | U[c] | U | U | U |
| $E_t$ (longitudinal), $10^6$ psi | 43.1 | 39.8 | 36.8 | 31.3 |
| $E_t$ (transverse), $10^6$ psi | 41.6 | 40.2 | 36.1 | 31.6 |
| **Compression** | | | | |
| $F_{cy}$ (longitudinal), ksi | 58.3 | 52.7 | 48.0 | 39.8 |
| $F_{cy}$ (transverse), ksi | 57.8 | 52.7 | 46.2 | 39.3 |
| $E_c$ (longitudinal), $10^6$ psi | 42.5 | 39.8 | 39.3 | 38.1 |
| $E_c$ (transverse), $10^6$ psi | 40.8 | 40.7 | 40.0 | 38.7 |
| **Impact** (V-notch Charpy) | U[c] | U | U | U |
| **Fracture Toughness** ($K_{Ic}$)[d] | (No pop-in)[d] | U | U | U |
| **Bend**, min. radius | (Fracture) | U | 32T | 10T |

BERYLLIUM SHEET DATA (Continued)

| Properties | Temperature, F | | | |
|---|---|---|---|---|
| | RT | 400 | 600 | 800 |
| **Shear** | | | | |
| $F_{su}$ (longitudinal), ksi | 34.8 | U | U | U |
| $F_{su}$ (transverse), ksi | 33.4 | U | U | U |
| **Axial Fatigue** (Transverse) | | | | |
| Unnotched, R = 0.1[e] | | | | |
| $10^3$ cycles, ksi | 76 | 57 | 58 | U |
| $10^5$ cycles, ksi | 61 | 56 | 49 | U |
| $10^7$ cycles, ksi | 50 | 43 | 40 | U |
| $K_t$ = 3.0, R = 0.1 | | | | |
| $10^3$ cycles, ksi | 67 | 67 | 67 | U |
| $10^5$ cycles, ksi | 33 | 31 | 27 | U |
| $10^7$ cycles, ksi | 28 | 20 | 17 | U |
| **Creep** (Transverse) | | | | |
| 0.5% elongation 100 hr, ksi | NA[c] | 43 | 42 | 20 |
| 0.5% elongation 1000 hr, ksi | NA | 42 | 40 | 15 |
| **Stress Rupture** (Transverse) | | | | |
| Rupture 100 hr, ksi | NA | 48 | 42 | 27 |
| Rupture 1000 hr, ksi | NA | 44 | 39 | 20 |
| **Stress Corrosion** | | | | |
| 80% $F_{ty}$, 1000 hr max. | (No cracks)[f] | U | U | U |
| **Coefficient of Thermal Expansion**, in./in./F | | | | |
| (77-212 F) 6.4 x $10^6$[g] | | | | |
| (77-800 F) 8.3 x $10^6$[h] | | | | |
| **Density**, lb/in.$^3$ 0.066[g] | | | | |

(a) Values are from tests conducted at Battelle under the subject contract unless otherwise indicated. In most cases values are average of triplicate test. Fatigue, creep, and stress-rupture values are from data curves generated using the results of a greater number of tests.

(b) All specimens etched: 20 percent nitric acid, 1 percent sulfuric acid by volume, water balance (temperature 80-90 F) to remove any surface damage or residual stresses caused by machining.

(c) NA, not applicable; U, unavailable.

(d) Fatigue cracked center notched specimen 3 x 12 inch. Fracture data not reliable – specimens failed at grip ends and in bolt holes.

(e) "R" represents algebraic ratio of the minimum stress to the maximum stress in one cycle, that is, $R = S_{min}/S_{max}$. "$K_t$" represents Neuber-Peterson theoretical stress concentration factor.

(f) Alternate immersion, 3-1/2 percent NaCl, 3-point loading bend test.

(g) Values from Reference (1).

(h) Values from Reference (2).

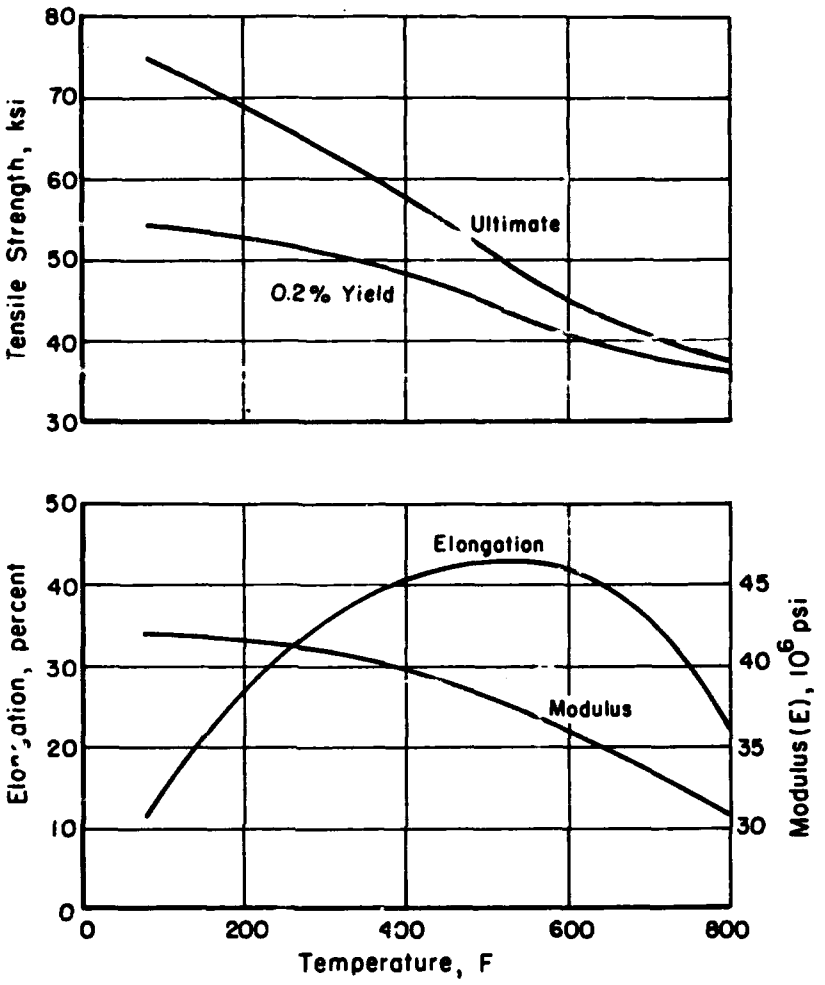



FIGURE 1. EFFECT OF TEMPERATURE ON THE TENSILE PROPERTIES OF CROSS-ROLLED BERYLLIUM SHEET

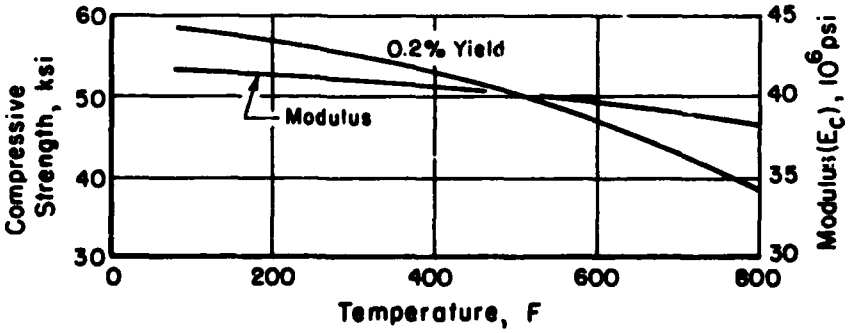



FIGURE 2. EFFECT OF TEMPERATURE ON THE COMPRESSIVE PROPERTIES OF CROSS-ROLLED BERYLLIUM SHEET

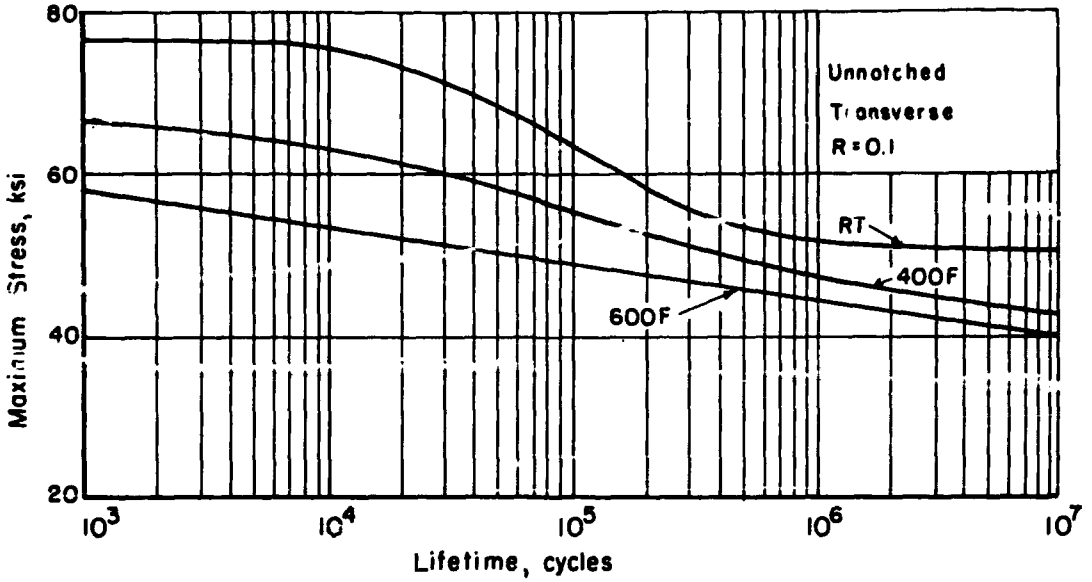



FIGURE 3. AXIAL-LOAD FATIGUE RESULTS FOR CROSS-ROLLED BERYLLIUM SHEET

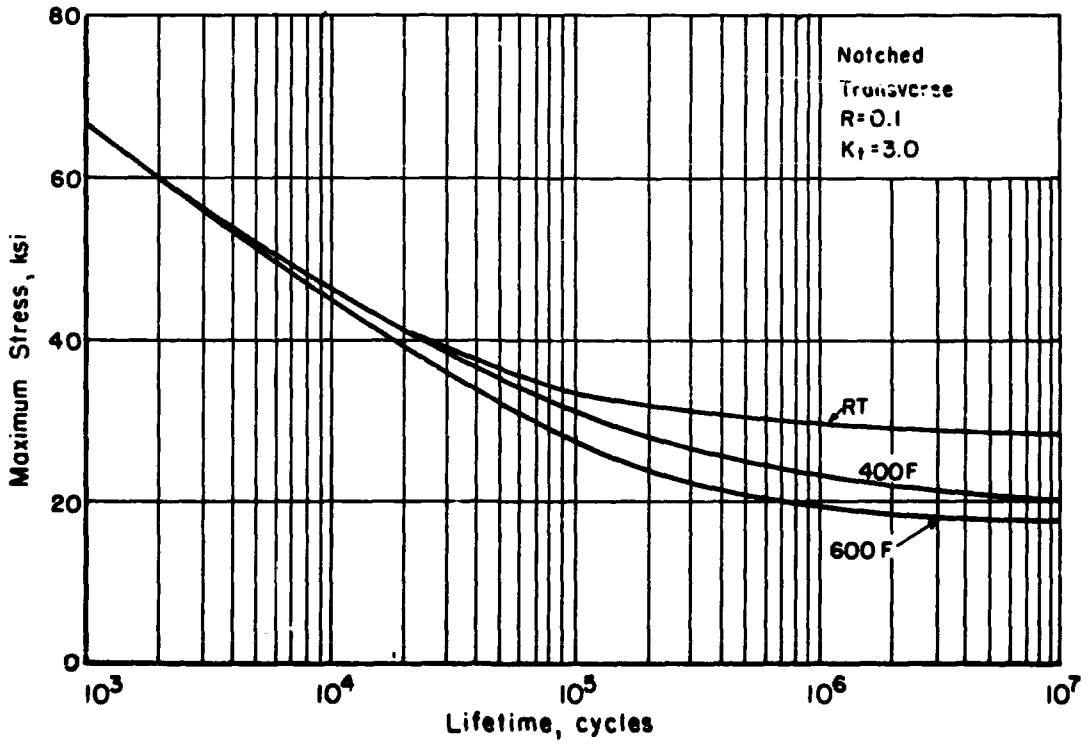
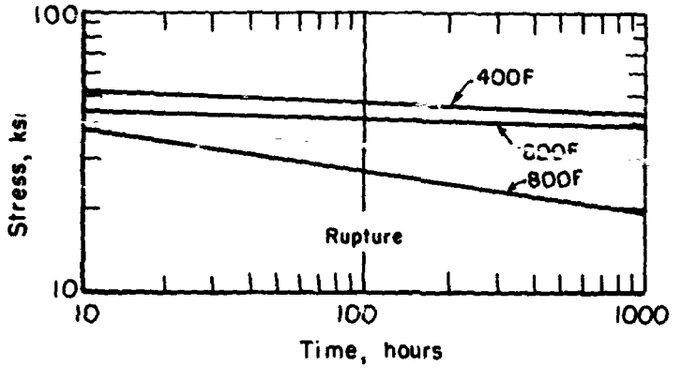



FIGURE 4. AXIAL-LOAD FATIGUE RESULTS FOR NOTCHED ($K_t$ = 3.0) CROSS-ROLLED BERYLLIUM SHEET



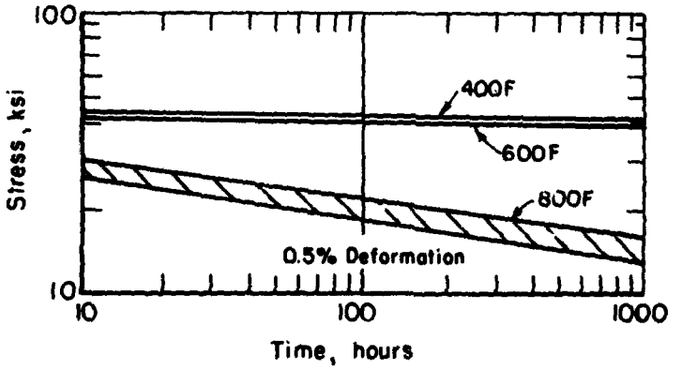




FIGURE 5. STRESS-RUPTURE AND 0.5% DEFORMATION CURVES FOR CROSS-ROLLED BERYLLIUM SHEET

## REFERENCES


(1) "Metallic Materials and Elements for Aerospace Vehicle Structures", MIL-HDBK-5A (February 8, 1966).

(2) "Beryllium Properties and Products", Bulletin 2100, The Beryllium Corporation (September, 1965).